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"*We only have the one*": Mapping the prevalence of people with high body mass to aid regional emergency management planning in Aotearoa New Zealand

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ABSTRACT

Introduction: People have been left behind in disasters directly associated with their size, shape, and weight and are disproportionately impacted in pandemics. Despite alignment with known vulnerabilities such as poverty, age, and disability, the literature is inaudible on body mass. Emergency managers report little or no information on body mass prevalence. This exploratory study aimed to illustrate population prevalence of high body mass for emergency planning.

Methods: Cross-sectional data from the New Zealand Health Survey were pooled for the years 2013/14–2017/18 (n = 68 053 adults aged ≥15 years). Height and weight were measured and used to calculate body mass index. The prevalence of high body mass were mapped to emergency management boundary shapefiles. The resulting maps were piloted with emergency managers.

Results: Maps highlight the population prevalence of high body mass across emergency management regions, providing a visual tool. A pilot with 14 emergency managers assessed the utility of such mapping. On the basis of the visual information, the tool prompted 12 emergency managers to consider such groups in regional planning and to discuss needs.

Conclusions: Visual mapping is a useful tool to highlight population prevalence of groups likely to be at higher risk in disasters. This is believed to be the first study to map high body mass for the purposes of emergency planning. Future research is required to identify prevalence at a finer geographical scale. More features in the local context such as physical location features, risk and vulnerability features could also be included in future research.

1. Introduction

1.1. High body mass

The prevalence of adults living with high body mass is associated with reported increased risk of a plethora of adverse health outcomes [1]. Aotearoa New Zealand (NZ) is amongst the countries with the highest rates of obesity worldwide [2]. The prevalence of high body mass increases with age [1], with rates peaking in the 55–64 age group in NZ [3]. Obesity is typically defined by a Body Mass Index (BMI) of greater or equal to 30 kg/m^2 [4]. High body mass such as weighing ≥150 kg, or having a BMI ≥35 kg/m^2, are associated with mobility limitations [5,6] and this can make moving and evacuation more difficult in emergency situations [7–9]. The two highest categories of body mass are the focus of this paper: class II (severe) and class III (extreme) obesity. In the context of pandemic emergencies an association between high body mass and severity of illness and risk of death was reported with influenza A (H1N1) 2009 even after adjustment for co-conditions known to be a risk, although the exact relationship was not yet fully understood or defined [10–12]. Strong associations are currently being reported for obesity and SARS-COV-2 novel coronavirus (COVID-19) [13].

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1.2. High body mass and disasters

There is a significant gap in research relating to how people with high body mass are considered in disasters despite accounts that people have been left behind in direct relation to their size, shape, and weight [8,14–17]. While everyone is at risk of harm in a disaster, some people have been identified at higher risk in relation to their particular circumstances before, during, and following a disaster: this includes, but is not limited to, people from socioeconomically deprived areas, adults with severe mental illness, older people, people with chronic health conditions, gender minorities and people with disabilities [18–21]. Gray identified that many such populations also intersect with increased prevalence of high body mass and refers to this as 'triple jeopardy' [22]. Of concern, recent research shows that emergency managers, planners and responders (EMs) may underestimate prevalence of high body mass in their area of responsibility, recalling only those individuals where prior or intensive assistance had been involved, such as movement from home to hospital in relation to health care needs. Several EMs recalled *"we only have the one in our area"* when the researcher knew this not to be the case from experience, health statistics, and interactions with community members [23]. Some EMs deferred to health agencies, expecting they would notify EMs of any specific needs or priorities. Such assumptions are concerning and present profound implications for those individuals with high body mass who are generally well or who may refrain from interaction with local community and health providers, yet may present very specific needs in the event of a disaster [23].

1.3. Geographical Information Systems in emergency management

The popularity of information technology use in emergency management is increasing as EMs rely on varying software to assist with response [24,25]. Research has identified the practical and effectiveness of using such software including Geographical Information Systems (GIS) in emergency management. Working with The Red Cross, National Disaster Management Agency (NaDMA), and local communities in the small Caribbean nation of Grenada, Canevari-Luzardo et al. [26], facilitated mapping household vulnerability and hazards as a method to reduce risk and vulnerability. By using GIS, community members were able to indicate areas that they considered vulnerable and at risk of landslides, hurricanes and flooding. The maps produced were practical and accessible ensuring the usability by community members. A further example of the effectiveness of GIS use in disaster planning and risk assessment was highlighted in research conducted in Toronto [27] that mapped the social, physical, infrastructure and economic vulnerabilities that may contribute towards higher levels of risk. Their research demonstrated the complex and multiple levels of vulnerability in a given population. The authors argue for the use of GIS in risk assessments in order to produce greater awareness of the multiple risks across a diverse population. Since Hurricane Andrew devastated the Southern Coast of Florida in 1992, there has been a rapid increase in the use of GIS in the USA state and federal government, notably Federal Emergency Management Agency (FEMA) to assist with mitigation, preparation, response and recovery [24]. A crucial component of GIS is to support effective deployment of response resources to critical areas in real-time [24]. In NZ information systems have not been utilised to their full potential by EMs [25]. Utilising information technology can assist in meeting EMs needs in identifying high risk areas and the needs of the population by facilitating effective preparations and response to a natural hazard event.

1.4. Geographical information and high body mass for emergency planning

Geographic Information Systems (GIS) have the potential to effectively deliver visual data such as, the prevalence of those individuals with high body mass. Indeed, as information technology has evolved, we have seen increased frequency of health communication with disease maps [28,29]. We also now live in an increasingly visual society, where most of us see and process images more than we read words [30]. Visual mapping has been shown to improve understanding of hazard information when compared to tables and written material [31–33]. Therefore, a map or spatial depiction of where at risk populations are is a key medium for communicating such information. For example, hazard maps are routinely utilised by scientists to relay information concerning volcanic hazards to many different recipients [34]. Such information, how it is relayed and how it is interpreted quickly, has specific utility during rapidly evolving and potentially major events *"people tend to rely more on their initial impressions and intuitive feelings about hazard and risk than on exhaustive analytical evaluation of hazard and risk information"* [35], p.622]. The value of having simple and clear hazard maps for use in crisis communication has been consistently demonstrated for instance, within volcanic crises or wildfire events [34].

Thompson [34] highlights the work of Lester [30], Carrasco [36], Domke, Perimutter and Sprattl [37], Mould and Mandryk [38] to underline the benefit of images over written words to grab attention. This has been utilised very successfully by the Centres for Disease Control and Prevention to show the changes in body mass prevalence over time in the USA [39]. However, this has never to the authors' knowledge previously been applied to show prevalence of those with high body mass in relation to disaster management.

The failure to incorporate high body mass prevalence in disaster management has produced a significant and important gap in current evidence as maps allow the influence of decision-making without the barrier of literacy or linguistics. Hobbs and colleagues have extensively applied GIS mapping techniques to describe the spatial and spatio-temporal patterning of health outcomes and environmental exposures [40–42]. While consideration is required to ensure confidentiality and interpretation of prevalence data to small geographic areas, the development of a mapping resource can help better inform emergency planning [29].

Communicating the risks of natural hazards to EMs and the public is regarded as essential in reducing vulnerability and supporting effective coordination [43,44]. Effective communication of risk is also dependent on how information is received and processed [45]. Good communication between scientists and EMs can mitigate or accentuate risk, in particular for vulnerable individuals and groups [45]. Communicating scientific information to the public is an established area of research [43, 46–48]. Effective communication between scientists and EMs enables timely decision making and the coordination of response [49]. Demuth et al. [49] argue that a challenge is that data can be technical and too detailed, thus is difficult for EMs and policy makers to understand. Therefore, only practical and essential information needs to be communicated to decision makers. Poor communication can lead to failure in effectively responding to a disaster event as was seen during Hurricane Katrina. The hurricane forecasting was correct, yet senior EMs and policy makers did not engage adequately with the data, thus delaying evacuation putting people at high risk [44]. A good understanding of data can strengthen preparation and response; presenting information clearly to EMs is essential. Scholars argue that positive disaster response develops by integrating data from multiple agencies and sources opposed to the more common hierarchical structures of response [44,50].

This paper describes an exploratory study and the development of a visual mapping resource for EMs to gain better insight into the prevalence of people with high body mass in each Civil Defence Emergency Management (CDEM) area in NZ providing rigorous and original evidence on an often overlooked topic internationally.

2. Methods

2.1. This study used cross-sectional data that was pooled for the year 2013/14–2017/18 from the New Zealand Health Survey. These data were then applied to the geographical boundary areas of each CDEM area in order to provide visual representation for high body mass prevalence.

2.1. Study setting

The study setting was nationwide data across NZ and involved designated regional boundaries identified by NEMA. Fig. 1 shows the different geographical boundaries of each CDEM area.

2.2. Data sources

Cross-sectional data from the New Zealand Health Survey (NZHS) were pooled for the five years of 2013/14–2017/18 (n = 68 053 adults aged ≥15 years). Data on body mass were obtained from the adult NZHS that provides information on a range of sociodemographic, health behaviours, and self-reported health status. As outlined elsewhere [40] the survey uses a multistage sampling method for participants who reside within NZ. Results are then weighted to account for survey design, oversampling and non-response in height and weight-related questions. Additional details are provided elsewhere [51]. The NZ Ministry of Health assigned area-level summarised spatial data to survey responses based on the geographical area of the respondent and removed participant identifying information before data transfer [51]. This process ensures all data used in analyses are anonymised prior to our use. All de-identified data were password protected and kept in a secure computer facility accessible only to a named researcher (51).

Data were obtained for measured BMI for each participant. All respondents had their height and weight measurements taken by the interviewer at the end of the survey. Height (cm) and weight (kg) of the participant was measured by a trained interviewer. A laser height measuring device consisted of a professional laser meter (Precaster HANS CA770) and weight was measured with electronic weighing scales (Tanita HD-351) [51]. A standardised protocol was followed and interviewers were re-trained annually and had to pass a recertification assessment to ensure they maintained the required skill levels to calculate BMI (weight in kg/height in metres^2). While it is not a direct measure of body fat, previous research has shown that BMI is a useful population level measure in large epidemiological studies [52]. For the purposes of this study, data were mapped for participants with class II body mass (BMI≥35.00–39.99) and class III body mass (BMI≥40.00). These are standardised categories in obesity statistics and provide comparison across the two highest body mass classifications routinely reported.

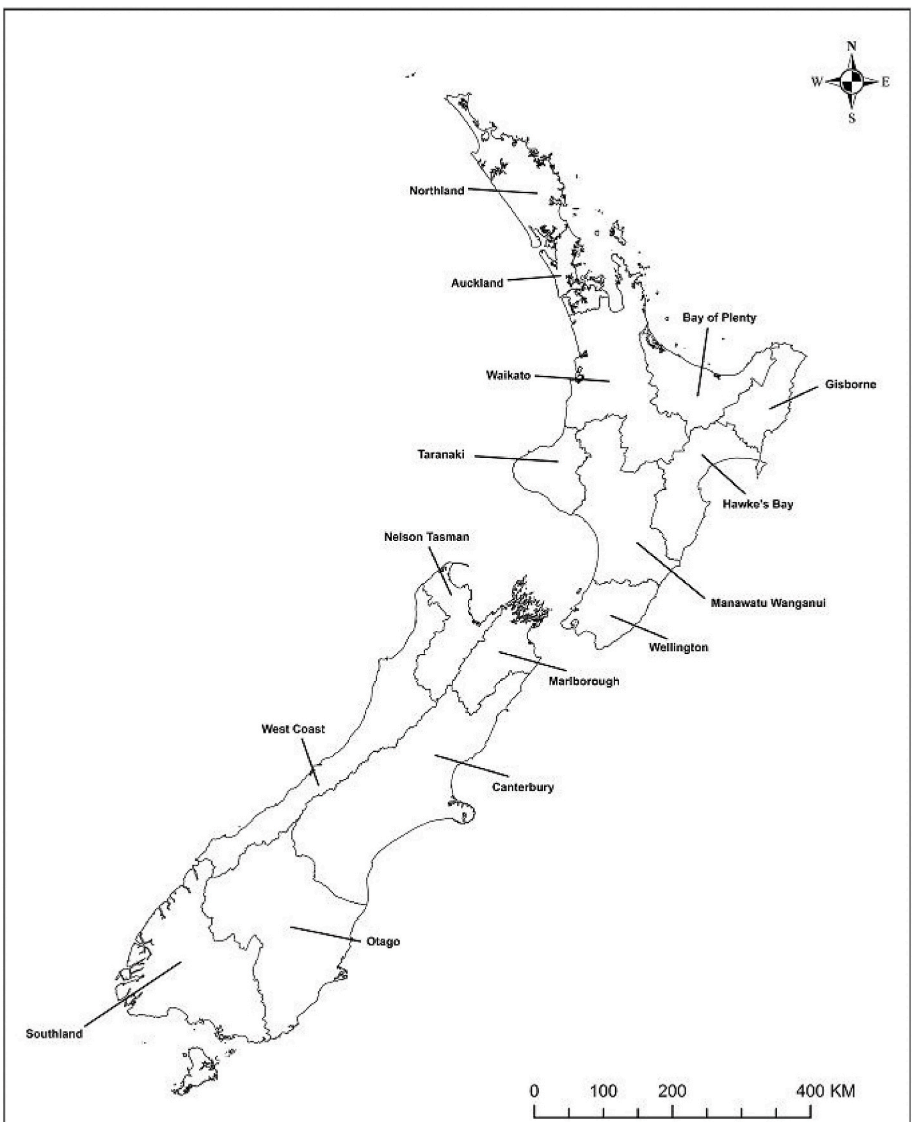

Fig. 1. Geographical boundaries denoting each CDEM group area.

2.3. Data visualisation

Shapefiles (a geospatial vector data format for geographic information system software) were provided by the National Emergency Management Agency (NEMA) (formerly the Ministry of Civil Defence and Emergency Management) under Crown Copyright and restricted access for the purpose of academic research. Boundaries were visualised within ArcGIS V10.7. Meshblocks within each NEMA boundary were then joined based on spatial location if the population weighted centroid of the meshblock was within the NEMA boundary. Meshblocks are defined by Statistics New Zealand as the smallest geographic unit for which statistical data is collected and processed (the 2013 Census comprised 46 629 units, i.e. meshblocks). Data was obtained from NZDep2013, giving a deprivation score for each meshblock in NZ which were divided into quintiles (quintile one = least deprived) [53]. NZDep2013 includes material and social deprivation dimensions [49]. Data on obesity prevalence contained a meshblock identifier allowing the spatial join. Regional prevalence of high body mass were then mapped to nominated area boundaries for Civil Defence to provide a visual planning tool for EMs. Data were weighted to be nationally representative over the five years pooled data so the sum of the weights were equal to the average resident population of that time period. It should be noted that CDEM area boundaries are not coterminous to area health authority boundaries in NZ.

2.4. Piloting

Piloting of the visual mapping material was conducted with 14 EMs attending the Emergency Management Summer Institute at Massey University, NZ (March 2020, Wellington NZ). Following an oral presentation of the mapping process and overview of issues for people with high body mass in previous disasters, paper copies of the prevalence maps were provided to EMs with a paper feedback form. Feedback was provided during the session to the presenting author via completion of the paper based feedback form and verbal comments.

3. Results

3.1. Overall, in this study sample, 7.7% [95% CI 7.4–7.9] of the adult population in NZ had class II body mass and 5.1% [4.9–5.3] had class III body mass. Overall, 12.8% [12.5–13.1] of the population had high body mass. When split by deprivation quintile, the highest prevalence of class II and class III body mass were seen in the most deprived areas (Quintile 1 (least deprived): 5.1% [4.6–5.7] and 2.3% [1.9–2.7]; Quintile 2: 6.0% [5.5–6.5] and 3.1% [2.8–3.6]; Quintile 3: 7.1% [6.5–7.6] and 4.2% [3.8–4.7]; Quintile 4: 8.6% [8.0–9.1] and 5.7% [5.2–6.1]; Quintile 5 (most deprived): 11.8% [11.3–12.4] and 10.4% [9.8–10.9]).

3.1. National profile

The prevalence of high body mass was geographically mapped to CDEM boundary areas (Table 1). High body mass are depicted visually within Fig. 2. The highest prevalence was in rural and provincial areas of NZ: Southland (16.7% [14.5–19.2]), Gisborne (15.9% [13.9–18.2]) and Hawke's Bay (15.7% [14.4–17.2]) while the lowest was in Marlborough (9.0% [7.3–11.1]), Nelson Tasman (9.4% [8.0–10.9]), and Canterbury (10.0% [10.1–11.9]). Class II body mass was highest in Hawke's Bay (9.7% [8.6–10.9]), Southland (9.1% [7.5–11.0]), and Northland (9.0% [8.0–10.2]), while the lowest was in Marlborough (5.9% [4.5–7.8]), Nelson Tasman (6.1% [5.0–7.5]), and Canterbury (6.9% [6.2–7.6]). For class III body mass, the highest prevalence was in Southland (7.6% [6.1–9.5]), Gisborne (7.5% [6.1–9.1]), and Manawatu-Wanganui (6.4% [5.6–7.3]). The combined class II and class III body mass prevalence is shown within Fig. 3.

Table 1
The prevalence of high body mass by Civil Defence and Emergency Management boundary (weighted % [95% Confidence Intervals]).

Civil Defence and Emergency Management area	BMI≥35–39.99 (class II/severe) weighted% [95% CI]	BMI≥40 (class III/extreme) weighted% [95% CI]	Weighted percentage with class II severe and class III extreme weighted% [95% CI]
Auckland (n=19 393)	7.5 [7.0 – 8.0]	5.4 [5.0 – 5.8]	12.8 [12.3 – 13.5]
Bay of Plenty (n = 4797)	8.0 [7.2–8.8]	4.9 [4.3–5.5]	12.9 [11.9–13.9]
Canterbury (n = 8410)	6.9 [6.2–7.6]	4.1 [3.6–4.7]	10.9 [10.1–11.9]
Gisborne (n = 581)	8.4 [7.0–10.2]	7.5 [6.1–9.1]	15.9 [13.9–18.2]
Hawke's Bay (n = 2425)	9.7 [8.6–10.9]	6.0 [5.2–7.0]	15.7 [14.4–17.2]
Manawatu Wanganui (n = 3185)	8.8 [7.9–9.8]	6.4 [5.6–7.3]	15.2 [14.0–16.5]
Marlborough (n = 744)	5.9 [4.5–7.8]	3.1 [2.2–4.3]	9.0 [7.3–11.1]
Nelson Tasman (n = 1521)	6.1 [5.0–7.5]	3.3 [2.5–4.3]	9.4 [8.0–10.9]
Northland (n = 2381)	9.0 [8.0–10.2]	6.0 [5.1–6.9]	15.0 [13.7–16.4]
Otago (n = 3315)	7.0 [6.0–8.1]	3.8 [3.0–4.7]	10.8 [9.5–12.1]
Southland (n = 1524)	9.1 [7.5–11.0]	7.6 [6.1–9.5]	16.7 [14.5–19.2]
Taranaki (n = 1700)	7.4 [6.3–8.7]	5.0 [4.0–6.1]	12.4 [11.0–14.0]
Waikato (n = 5754)	8.8 [8.0–9.7]	6.1 [5.4–6.9]	14.9 [13.8–16.0]
Wellington (n = 7610)	6.9 [6.2–7.6]	4.4 [3.9–4.9]	11.3 [10.5–12.1]
West Coast (n = 430)	8.3 [6.6–10.4]	5.1 [3.7–7.1]	13.4 [11.2–16.1]

N = the total number of people within each area.

3.2. National profile by area-level deprivation

The prevalence of high body mass was split according to CDEM boundary areas and by area-level deprivation quintile (Table 2). Confidentiality is protected as data are only presented when there are at least 30 people in the cell as a denominator. Care should also be taken when interpreting these findings due to low numbers of participants in particular within the West Coast, Gisborne, Marlborough, Nelson Tasman, Southland, and Northland (Q1 and Q2) areas. Despite the caveat of smaller numbers in some areas, there was a consistent gradient exhibited with a higher prevalence of high body mass in the most socioeconomically deprived areas (see supplementary materials for further analysis). In Auckland for instance where one quarter of the whole NZ population live, 28.9% were in the most deprived areas compared to 5.9% in the least deprived quintile.

3.3. Feedback from EMs

Written feedback from most EMs present welcomed data presented in this way and this prompted many questions about disaster risk reduction and needs of people with high body mass. An example of typical written feedback is *"the more that I think about it, the more I am thinking that it [considerations for people with high body mass] does involve some serious work"* (EM pilot participant number 3). Two EMs felt the data provided at regional level was illustrative but felt more local level geographical data was required to be meaningful for emergency management. Many EMs agreed the prevalence maps were *"an eye opener"* (EM pilot participant number 8) and prompted about half of the EMs present to seek detailed further information from the presenting author over the session break.

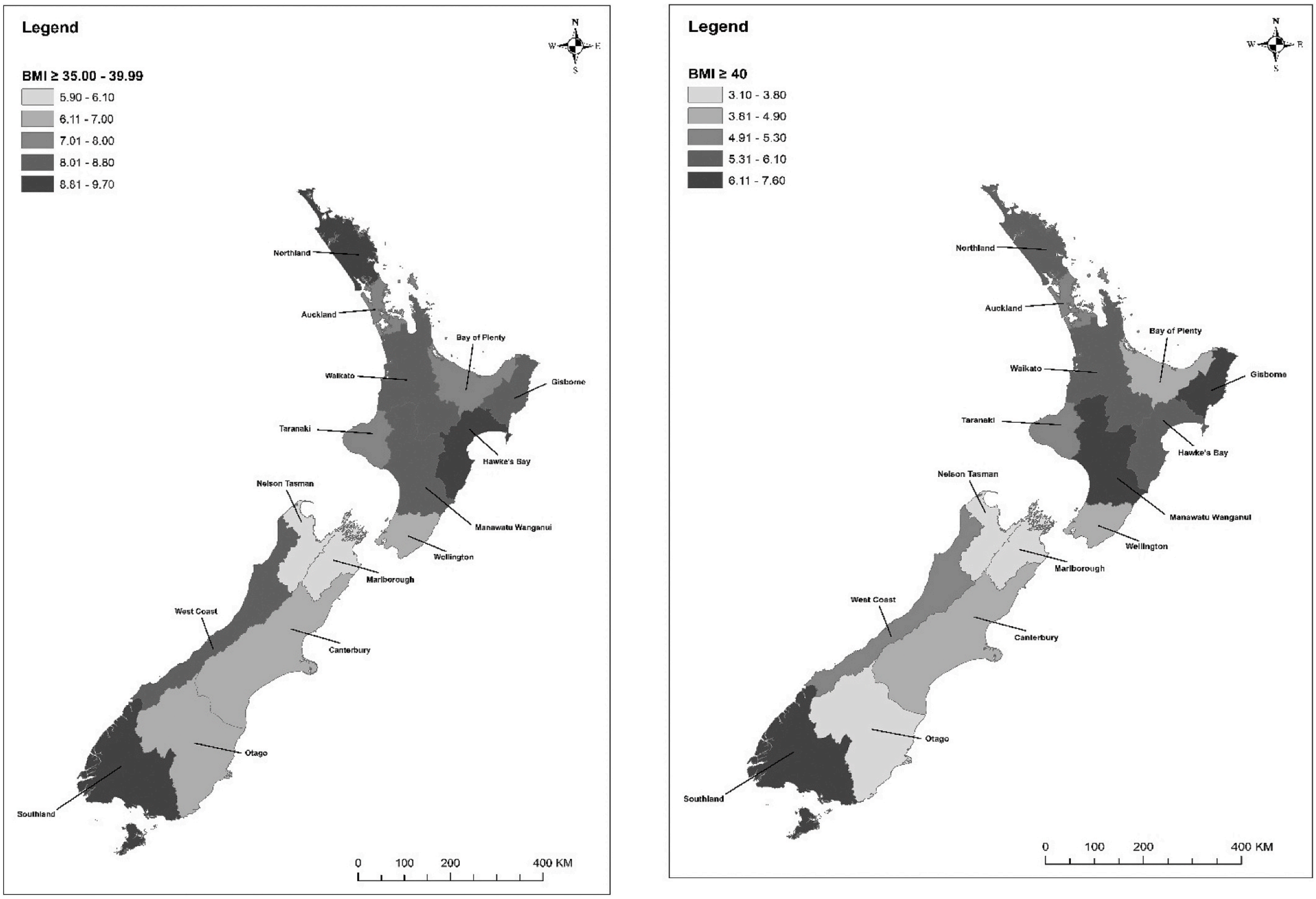

Fig. 2. The prevalence of high body mass (Panel A) and very high body mass (Panel B) for CDEM boundary areas by quintile.

4. Discussion

4.1. Our study developed one of the first visual mapping resources for emergency managers, planners and responders (EMs) to gain better insight into the prevalence of people with high body mass in each emergency management area of NZ. Uniquely, this study combines rigorous nationally representative and pooled data over four years with measured height and weight. This was in response to underestimations of the levels of people with high body mass by EMs in a recent multi-methods study [23], despite recognition of heightened risks associated with disability, long term conditions, older people and people who are socio-economically deprived. People with high body mass are over-represented in such groups and yet are overlooked in relation to their particular disaster risk reduction needs internationally [8,22,23].

4.1. More people with higher body mass

While increased action in childhood obesity prevention efforts is occurring [54], no Country's public health obesity strategy appears to have sustained a reduction in population body mass to date [55]. Further, we have seen increases in adults from high to higher BMI with age, and increasing levels in low and middle income countries in addition to high income countries [1,56]. This has international relevance for disaster risk reduction considerations. For instance, it is estimated that by the year 2025 there will be more women with severe (class II) body mass (BMI 35–39 kg/m^2) than women with underweight [1] and with increasing age this suggests those with class II body mass will move to extreme (class III) body mass over time rather than a trend downwards. In terms of numbers of adults likely to have high body mass, the numbers are not insignificant in NZ: those with a BMI 35–39 (kg/m^2) are estimated around 314 000 adults (8% of the adult population) and those with a BMI greater than 40 (kg/m^2) estimated to be 181 000 adults, (4.6% of the adult population) [3]. When identifying risks and vulnerabilities EMs need to include prevalence of high body mass for their area of responsibility to determine any additional considerations for already vulnerable populations.

4.2. Depicting emergency management area prevalence of high body mass

Of particular note, Southland area prevalence is highest in the most deprived areas but also notably high in quintile 2 and quintile 3 relative to other areas. Indeed, the social gradient shown across all areas where a higher prevalence of high body mass exists in the most deprived areas should be an important consideration for any emergency management service wishing to estimate prevalence of high body mass for its population. The weighted percentage was also higher in predominantly more rural northerly areas of the North Island of NZ in areas such as Gisborne, Hawke's Bay and Bay of Plenty. These finding may align with global data from the NCD Risk Collaborative showing increases in rural BMI is fueling more than 50% of the rise in BMI globally during the last three decades [57]. However, recent data in New Zealand shows that the semi-urban areas (not urban not rural) may have the greatest prevalence of poor health including higher levels of obesity [58]. Therefore, this is an area that requires further research, particularly given the challenges of working in rural areas for EMs [59].

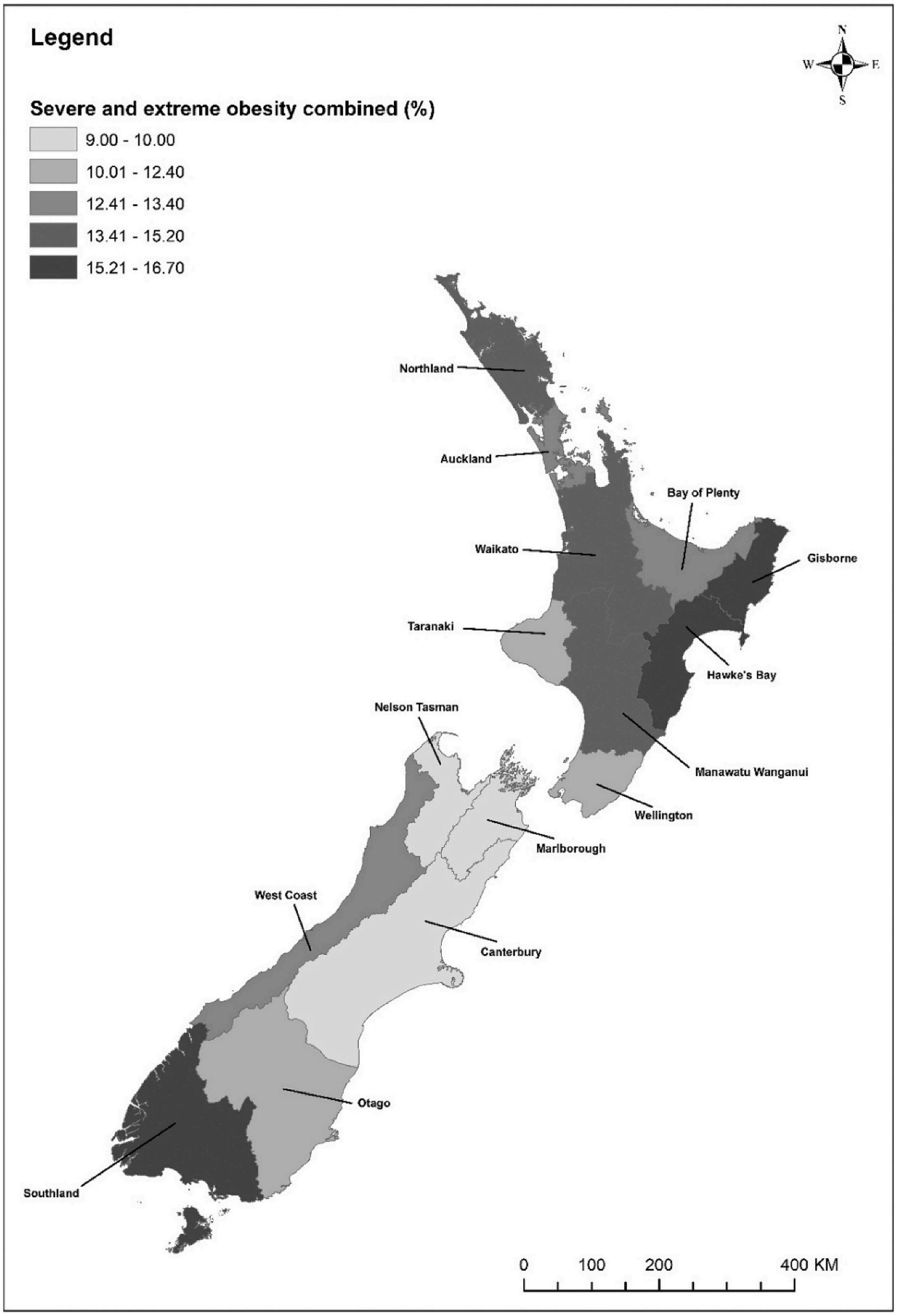

Fig. 3. The prevalence of combined severe and extreme obesity by CDEM boundary areas by quintile.

4.3. Policy and practice implications

Importantly for EMs, people with high body mass may require equipment with higher weight and width ratings that may not usually be held in stock in all CDEM areas. Education around the complex causes of obesity, and the contribution of stigma and bias should be available to EMs. CDEM areas should review equipment utilised in evacuation or temporary shelter for its width and weight capacities and encourage local designated community emergency centres to consider local need. For example, a lot of health equipment is only rated up to $\geq$150 kg [5,7,60] and basic office type chairs found in local community centres are unlikely to have higher weight ratings. It is also pertinent to note that while many people with high body mass weigh less than 150 kg, wider/larger sized equipment may still be required to avoid harm caused by pressure injury or trapped skin [61]. Provision of chairs with no armrests or benches that can accommodate one or two persons are simple solutions for local centres where displaced people may congregate. Wider rollaway beds can be purchased, although centres should check the weight ratings of items before use. People with high body mass are very concerned about dignity and access to suitable size clothing in an emergency, worry about toileting requirements in temporary shelter, have a great fear of falling and embarrassment about needing multiple people to assist them to get up [9,62]. These may also be factors in not being able to take protective actions such as ‘drop, cover, hold’ in the event of a major earthquake [63]. Personnel will be required to assist a person with high body mass in the case of a fall or reduced mobility evacuation and extra time will be required for movement [9,62].

Table 2
The prevalence with severe and extreme obesity total by CDEM boundary areas (data are weighted % and [associated weighted 95% confidence intervals]).

CDEM boundary areas	Deprivation Quintile				
	Q1 (least deprived) Number (weighted%[95% CI]	Q2 Number (weighted %[95% CI]	Q3 Number weighted% [95% CI]	Q4 Number (weighted %[95% CI]	Q5 (most deprived) Number (weighted%[95% CI]
Auckland (n = 19 393)	135/2277 (5.9 [4.9–7.2])	179/2539 (7.1 [6.0–8.2])	271/2678 (10.1 [8.9–11.5])	413/2932 (14.1 [12.7–15.6])	1155/3.977 (28.9 [27.2–30.5])
Bay of Plenty (n = 4797)	32/411 (7.7 [5.1–11.5])	46/749 (6.1 [4.5–8.4])	143/1278 (11.2 [9.4–13.3])	176/1188 (14.9 [12.6–17.4])	403/2041 (19.8 [17.8–21.9])
Canterbury (n = 8410)	94/1215 (7.7 [6.2–9.6])	152/1424 (10.7 [8.9–12.8])	161/1408 (11.4 [9.7–13.5])	192/1572 (12.2 [10.3–14.3])	171/1078 (16.0 [13.4–18.9])
Gisborne (n = 581)	6/81 (8.2 [3.3–18.5])	*	*	61/483 (12.8 [9.8–16.7])	147/696 (21.1 [17.9–24.7])
Hawke's Bay (n = 2425)	17/246 (7.2 [4.5–11.3]	28/312 (9.0 [6.1–13.0])	77/606 (12.7 [9.9–15.9])	125/820 (15.4 [12.7–18.5])	337/1398 (24.1 [21.5–27.0])
Manawatu Wanganui (n = 3185)	28/332 (8.6 [5.5–13.1])	72/576 (12.5 [9.7–16.0])	94/796 (11.9 [9.5–14.6])	217/1281 (17.0 [14.7–19.5])	326/1624 (20.1 [17.8–22.6])
Marlborough (n = 744)	*	*	40/373 (10.9 [7.8–15.1])	33/268 (12.6 [8.9–17.3])	*
Nelson Tasman (n = 1521)	*	+20/355 (5.7 [3.6–9.1])	+53/501 (10.7 [8.1–13.9])	+52/541 (9.7 [7.1–12.9])	+35/248 (14.1 [9.9–19.7])
Northland (n = 2381)	*	*	42/491 (8.6 [6.4–11.6])	123/879 (14.1 [11.5–17.1])	329/1656 (19.9 [17.8–22.2])
Otago (n = 3315)	66/675 (9.8 [7.3–13.0])	47/557 (8.5 [6.1–11.5])	61/540 (11.3 [8.7–14.5])	88/597 (14.8 [11.7–18.4])	47/442 (10.7 [8.1–14.0])
Southland (n = 1524)	27/277 (9.9 [6.8–14.3])	54/292 (18.7 [13.7–25.2])	76/402 (18.9 [14.4–24.4])	41/248 (16.7 [12.2–22.3])	+69/325 (21.5 [16.7–27.2])
Taranaki (n = 1700)	*	43/421 (10.3 [7.4–14.1])	62/521 (11.9 [8.9–15.6])	97/738 (13.2 [10.5–16.4])	92/621 (14.9 [11.9–18.5])
Waikato (n = 5754)	49/532 (9.2 [6.7–12.5])	89/683 (13.1 [10.4–16.4])	123/956 (13.0 [10.6–15.7])	231/1503 (15.4 [13.4–17.6])	339/1709 (19.8 [17.7–22.2])
Wellington (n = 7610)	126/1681 (7.5 [6.2–9.1])	140/1544 (9.0 [7.6–10.7]	163/1489 (11.0 [9.3–13.0])	250/1717 (14.6 [12.6–16.8])	297/1400 (21.3 [18.7–24.1])
West Coast (n = 430)	*	+31/254 (12.3 [8.6–17.3])	+31/262 (12.1 [8.1–17.7])	+40/318 (12.7 [9.1–17.3])	*

* In line with the NZHS methodology report and to ensure the survey data presented are reliable and the respondents' confidentiality is protected, data are only presented when there are at least 30 people in the denominator. This ensures care is taken so no respondent can be identified in the results. + Care should be taken when interpreting findings due to low numbers in this cell and wide confidence interval.
Data represent number with severe or extreme obesity/total of population (not extreme and with severe or extreme obesity).

4.4. *Utility of GIS in emergency planning*

Disaster planning requires a good understanding of the geographical dimensions, boundaries, lifelines and important facilities [64] with advances in health data it is also possible to include key human health geography. The promise of GIS mapping include the potential to reach a broad array of audiences, including health planners, policymakers, advocacy groups, and an interested public [65]. Although this movement promotes creative means of analysis and identification of at-risk populations for planners and researchers, such accessibility may pose dilemmas relating to labelling populations living in particular geographic locales [40–42]. McBride [66] also argues that while maps are considered as trusted and useful communication tools they are also open to interpretation. As GIS is a visual tool, we recognise that mapping intended for a wide audience needs to ensure those with visual impairment are not excluded. Audio map equipment [67] and more recently 3D printing technology options are available [68] and need to be considered.

4.5. *High body mass in focus*

People with high body mass have been 'conspicuously invisible' in disaster risk reduction planning [8]. Those engaged in active health or hospital care at the time of an event or specific planning may be known to local agencies, hence the perception '*"we only have the one in our area"*' [23]. Whereas many people with high body mass will be going about their usual daily business with little active health care interaction and therefore invisible so far as EMs are concerned. Data presented as visual area maps offers a proxy for each area to give an indication of the likely affected population for planning purposes.

A strength of this study is the utilisation of pooled data over five years. In addition, the sample is nationally representative through weighting in the analysis, which also accounts for the missing data in height and weight measurements. Data for height and weight are objectively measured by trained individuals as part of the NZHS that reduces bias often found with self-reported data [69]. It is also one of the first times these data have been combined to result in a nationally representative large sample of pooled individuals with measured height and weight. While these are notable strengths the study is limited in the level of detail it can provide on the maps. For instance, the geographical areas presented are large and a finer or smaller geographical area may help EM better target specific areas. Despite this limitation, this study is exploratory in nature and provides an important first step toward mapping high body mass at a finer geographical scale in the future when such data is available.

5. Conclusion

To the authors knowledge, this study is believed to be the first of its kind to map the prevalence of high body mass to CDEM regions for the purposes of supporting disaster planning decisions for people with high body mass. While geographical areas presented are quite large, being able to discuss prevalence with EMs and talk through likely rates in an emergency management area allows for more nuanced discussion around planning considerations for vulnerable populations involving important stakeholders. When presented with data in an easy to use manner, EMs may better consider the needs of their regional population living with high body mass. The visual mapping in this study presents data to EMs with disaster risk reduction planning for populations likely to be at higher risk in disasters. Future research will test the utility of visual mapping in this study and while this study was exploratory in nature using coarse geographical areas, future research may benefit from exploring finer geographical scales to better pin point specific locations where EM may need to target.

Ethical approval

This study did not require ethical approval. Approval was sought from the National Emergency Management Agency (formerly the Ministry of Civil Defence and Emergency Management) to utilise the shapefiles/boundaries. Pilot testing with EMs was evaluated and judged to be low risk by Massey University, it did not require review by the University's Human Ethics Committee (ref: 4000018662).

Patient consent

Not required.

Contributions

Lesley Gray: Study conceptualisation, Literature search, Interpretation of results, manuscript preparation and final approval, Competing Interests statement. Ashleigh Rushton: Literature search, Interpretation of results, manuscript preparation and final approval, Competing Interests statement. Matthew Hobbs: Study conceptualisation, Literature search, Interpretation of results, manuscript preparation and final approval, Data mapping, tables and figures

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijdrr.2020.101859.

References

[1] NCD Risk Factor Collaboration, Trends in adult body-mass index in 200 countries from 1975 to 2014: a pooled analysis of 1698 population-based measurement studies with 19.2 million participants, *Lancet* 387 (2016) 1377–1396.
[2] World Health Organization, Prevalence of obesity amongst adults, aged 16+, 1975-2016, both sexes, Global Health Observatory (2017) [updated 29 October 2019], http://gamapserver.who.int/gho/interactive_charts/ncd/risk_factors/obesity/atlas.html. (Accessed 5 November 2019).
[3] Ministry of Health, Annual Update of Key Results 2018/19: New Zealand Health Survey, Ministry of Health NZ, 2019. https://www.health.govt.nz/publication/annual-update-key-results-2018-19-new-zealand-health-survey. (Accessed 14 December 2019).
[4] Ministry of Health, Understanding Excess Body Weight: New Zealand Health Survey, Ministry of Health, 2015. https://www.health.govt.nz/publication/understanding-excess-body-weight-new-zealand-health-survey. (Accessed 18 September 2019).
[5] S. Stenholm, P. Sainio, T. Rantanen, E. Alanen, S. Koskinen, Effect of co-morbidity on the association of high body mass index with walking limitation among men and women aged 55 years and older, Aging Clin. Exp. Res. 19 (4) (2007) 277–283.
[6] H.K. Vincent, K.R. Vincent, K.M. Lamb, Obesity and mobility disability in the older adult, Obes. Rev. 11 (8) (2010) 568–579.
[7] J. Geiling, Critical care of the morbidly obese in disaster, Crit. Care Clin. 26 (2010) 703–714.
[8] L. Gray, C. MacDonald, Morbid obesity in disasters: bringing the "conspicuously invisible" into focus, Int J Env Research and Public Health 13 (10) (2016) 1029.
[9] L. Gray, L. McAfee, E.J. McCrane, C. MacDonald, My grab bag is two suitcases: an autoethnographical view of a super-plus size self-evacuation from Hurricane Irma, Aust. J. Emerg. Manag. 3 (2018) 50–54.
[10] O.W. Morgan, A. Bramley, A. Fowlkes, D.S. Freedman, T.H. Taylor, P. Gargiullo, B. Belay, S. Jain, C. Cox, L. Kamimoto, A. Fiore, Morbid obesity as a risk factor for hospitalization and death due to 2009 pandemic influenza A (H1N1) disease, PloS One 5 (3) (2010) e9694, 2010.
[11] J.A. Moser, A. Galindo-Fraga, A.A. Ortiz-Hernández, W. Gu, S. Hunsberger, J. F. Galán-Herrera, M.L. Guerrero, G.M. Ruiz-Palacios, J.H. Beigel, La Red ILI 002 Study Group, Magaña-Aquino M. Underweight, overweight, and obesity as independent risk factors for hospitalization in adults and children from influenza and other respiratory viruses, Influenza and other respiratory viruses 13 (1) (2019) 3–9.
[12] E. Díaz, A. Rodríguez, I. Martin-Loeches, L. Lorente, M. del Mar Martín, J.C. Pozo, J.C. Montejo, A. Estella, Á. Arenzana, J. Rello, H1N1 SEMICYUC Working Group. Impact of obesity in patients infected with 2009 influenza A (H1N1), Chest 139 (2) (2011), 382-6.
[13] B.M. Popkin, S. Du, W.D. Green, M.A. Beck, T. Algaith, C.H. Herbst, R.F. Alsukait, M. Alluhidan, N. Alazemi, M. Shekar, Individuals with obesity and COVID-19: a global perspective on the epidemiology and biological relationships, Obes. Rev. (2020) 1–17.
[14] S. Fink, Five Days at Memorial: Life and Death at a Storm-Ravaged Hospital, Atlantic Books Ltd., New York, NY, USA, 2013.
[15] A.J. Ramme, V. Shaleen, T.M. McLaurin, Superstorm sandy's forgotten patient: a lesson in emergency preparedness in severe obesity, Obesity 23 (2015) 253–254.
[16] E.J.I. Apatu, D. Aga, E. Osland, C.E. Gregg, Strengthening public health and disaster resilience in American Samoa: the use of the precede-proceed model, Planet Risk 2 (2014) 363–369.
[17] J.D. Hughes, Chapter 7 responses to natural disasters in the Greek and roman world, in: K. Pfeifer, N. Pfeifer (Eds.), Forces of Nature and Cultural Responses, Springer, Heidleberg, Germany, 2013.
[18] J.S. Ringel, A. Chandra, M. Williams, K.A. Ricci, A. Felton, D.M. Adamson, M. Weden, M. Huang, Enhancing public health emergency preparedness for special needs populations: a toolkit for state and local planning and response, Rand Health Q 1 (2011) 19.
[19] B. Wisner, J. Gaillard, I. Kelman (Eds.), Disaster Risk, Routledge, London, UK, 2015.
[20] A. Rushton, L. Gray, J. Canty, K. Blanchard, Beyond Binary: (re)defining 'gender' for 21st Century disaster risk reduction research, policy and practice, Int. J. Environ. Res. Publ. Health 16 (20) (2019) 3984.
[21] I. Kelman, L. Stough (Eds.), Disability and Disaster: Explorations and Exchanges, Palgrave Macmillan, London, 2015.
[22] L. Gray, Social determinants of health, disaster vulnerability, severe and morbid obesity in adults: triple jeopardy? Int. J. Environ. Res. Publ. Health 14 (12) (2017) 1452.
[23] L. Gray, Preparing for the Big One: an exploratory study with emergency managers, planners and responders in Aotearoa New Zealand, in: QuakeCore Conference, Sept 2018. Taupō, New Zealand.
[24] C.T. Emrich, S.L. Cutter, P.J. Weschler, GIS and Emergency Management, The SAGE handbook of GIS and society, 2011, pp. 321–343.
[25] T.J. Huggins, R. Prasanna, Information technologies supporting emergency management controllers in New Zealand, Sustainability 12 (9) (2020) 3716.
[26] L. Canevari-Luzardo, J. Bastide, I. Choutet, D. Liverman, Using partial participatory GIS in vulnerability and disaster risk reduction in Grenada, Clim. Dev. 9 (2) (2017) 95–109.
[27] C. Armenakis, N. Nirupama, Prioritization of disaster risk in a community using GIS, Nat. Hazards 66 (1) (2013) 15–29.
[28] A.B. Lawson, Disease map reconstruction, Stat. Med. 20 (14) (2001) 2183–2204.
[29] B.S. Bell, R.E. Hoskins, L.W. Pickle, D. Wartenberg, Current practices in spatial analysis of cancer data: mapping health statistics to inform policymakers and the public, Int. J. Health Geogr. 5 (1) (2006) 49.
[30] P.M. Lester, Visual Communication: Images with Messages, sixth ed., Wadsworth, Cengage Learning, Boston, MA, 2014.
[31] Y. Cao, B.J. Boruff, I.M. McNeill, Is a picture worth a thousand words? Evaluating the effectiveness of maps for delivering wildfire warning information, Int J Disaster Risk Reduction 19 (2016) 179–196.
[32] L. Cheong, S. Bleisch, A. Kealy, K. Tolhurst, T. Wilkening, M. Duckham, Evaluating the impact of visualization of wildfire hazard upon decision-making under uncertainty, Int. J. Geogr. Inf. Sci. 30 (7) (2016) 1377–1404.
[33] D. Severtson, C. Vatovec, The theory-based influence of map features on risk beliefs: self-reports of what is seen and understood for maps depicting an environmental health hazard, J. Health Commun. 17 (2012) 836–856.
[34] M.L. Finucane, A. Alhakami, P. Slovic, S.M. Johnson, The affect heuristic in judgments of risks and benefits, J. Behav. Decis. Making 13 (1) (2000) 1–17.
[35] M.A. Thompson, J.M. Lindsay, G.S. Leonard, More than meets the eye: volcanic hazard map design and visual communication, Advs in Volcanology (2018) 621–640.
[36] M. Carrasco, Visual attention: the past 25 years, Vis. Res. 51 (2011) 1484–1525.
[37] D. Domke, D. Perimutter, M. Spratt, The primes of our times? An examination of the "power" of visual images, Journalism 3 (2002) 131–159.
[38] D. Mould, R.L. Mandryk, H. Li, Emotional response and visual attention to non-photorealistic images, Comput. Graph. 36 (2012) 658–672.

[39] Centers for Disease Control and Prevention. Adult Obesity Prevalence Maps. CDC. [updated 29 October 2019] https://www.cdc.gov/obesity/data/prevalence-maps.html#states (accessed on 5 November 2019).
[40] M. Hobbs, M. Tomintz, J. McCarthy, L. Marek, C. Vannier, M. Campbell, S. Kingham, Obesity risk in women of childbearing age in New Zealand: a nationally representative cross-sectional study, Int. J. Publ. Health 64 (4) (2019) 625–635.
[41] M. Hobbs, C. Griffiths, M.A. Green, H. Jordan, J. Saunders, J. McKenna, Associations between the combined physical activity environment, socioeconomic status, and obesity: a cross-sectional study, Perspectives in Public Health 138 (3) (2018) 169–172.
[42] C. Bowie, P. Beere, E. Griffin, M. Campbell, S. Kingham, Variation in Health and Social Equity in the Spaces where We Live: A Review of Previous Literature from the GeoHealth Laboratory, 2013. https://ir.canterbury.ac.nz/handle/10092/8906. (Accessed 17 March 2020).
[43] E.E.H. Doyle, J. Mcclure, D.M. Johnston, D. Paton, Communicating likelihoods and probabilities in forecasts of volcanic eruptions, J. Volcanol. Geoth. Res. 272 (2013) 1–15.
[44] L.K. Comfort, Crisis management in hindsight: cognition, communication, coordination, and control, Publ. Adm. Rev. 67 (SUPPL. 1) (2007) 189–197.
[45] H. Lazrus, B.H. Morrow, R.E. Morss, J.K. Lazo, Vulnerability beyond stereotypes: context and agency in hurricane risk communication, Weather Clim Soc 4 (2) (2012) 103–109.
[46] E.E.H. Doyle, D.M. Johnston, J. Mcclure, D. Paton, The communication of uncertain scientific advice during natural hazard events, N. Z. J. Psychol. 40 (4) (2011) 39–50.
[47] D.S. Mileti, P. Brien, Warnings during Disaster: normalizing communicated risk, Soc. Probl. 39 (1) (1992) 40–57.
[48] J.S. Becker, S.H. Potter, S.K. McBride, A. Wein, E.E.H. Doyle, D. Paton, When the earth doesn't stop shaking: how experiences over time influenced information needs, communication, and interpretation of aftershock information during the Canterbury Earthquake Sequence, New Zealand, Int J of Disaster Risk Reduction 34 (2019) 397–411.
[49] J.L. Demuth, R.E. Morss, B.H. Morrow, J.K. Lazo, Creation and communication of hurricane risk information, Bull. Am. Meteorol. Soc. 93 (8) (2012) 1133–1145.
[50] P. Rogers, J. Burnside-Lawry, J. Dragisic, C. Mills, Collaboration and communication: building a research agenda and way of working towards community disaster resilience, Disaster Prev. Manag. 25 (1) (2016) 75–90.
[51] Ministry of Health, Methodology Report 2017/18: New Zealand Health Survey, Ministry of Health NZ, 2019 [updated 2019], https://www.health.govt.nz/publication/methodology-report-2017-18-new-zealand-health-survey. (Accessed 15 January 2020).
[52] Asia Pacific Cohort Studies Collaboration, Body mass index and cardiovascular disease in the Asia-Pacific Region: an overview of 33 cohorts involving 310 000 participants, Int. J. Epidemiol. 33 (4) (2004) 751–758.
[53] J. Atkinson, C. Salmond, P. Crampton, NZDep2013 Index of Deprivation, Department of Public Health, University of Otago, Wellington, NZ, 2014. http://www.otago.ac.nz/wellington/research/hirp/otago020194.html. (Accessed 15 January 2020).
[54] Ministry of Health, Children and Young People Living Well and Staying Well: New Zealand Childhood Obesity Programme Baseline Report 2016/17 [updated 8 June 2017], Ministry of Health, Wellington, NZ, 2017 (accessed on 22 January 2020), https://www.health.govt.nz/publication/children-and-young-people-living-well-and-staying-well-new-zealand-childhood-obesity-programme.
[55] C.A. Roberto, B. Swinburn, C. Hawkes, T.T. Huang, S.A. Costa, M. Ashe, L. Zwicker, J.H. Cawley, K.D. Brownell, Patchy progress on obesity prevention: emerging examples, entrenched barriers, and new thinking", Lancet 385 (9985) (2015) 2400–2409.
[56] B.M. Popkin, M.M. Slining, New dynamics in global obesity facing low-and middle-income countries, Obes. Rev. 14 (2013) 11–20.
[57] NCD Risk Factor Collaboration, Rising rural body-mass index is the main driver of the global obesity epidemic in adults, Nature 569 (7755) (2019) 260.
[58] L. Marek, J. Wiki, M. Campbell, S. Kingham, C. Sabel, M. Tomintz, M. Hobbs, Slipping under the radar: worsened health outcomes in semi-urban areas of New Zealand, N. Z. Med. J. 133 (1519) (2020) 121–125.
[59] N. Kapucu, C.V. Hawkins, F.I. Rivera, Disaster preparedness and resilience for rural communities, Risk Hazards Crisis Publ. Pol. 4 (4) (2013) 215–233.
[60] J.M. Saunders, Vulnerable populations in an American red cross shelter after hurricane katrina, Psychiatr. Care 43 (2007) 30–37.
[61] L. Gardner, C. Gibbs, Class III obese patients: is your hospital equipped to address their needs, PA. *Patient Saf. Auth.* 10 (2013) 11–18.
[62] L Gray, J Becker, C MacDonald, D Johnston, Disaster risks identified by people with high body mass: A qualitative study, Obesity Reviews (13118) (2020), EP-463, https://doi.org/10.1111/obr.13118, 269–269 In this issue.
[63] S.K. McBride, J.S. Becker, D.M. Johnston, Exploring the barriers for people taking protective actions during the 2012 and 2015 New Zealand ShakeOut drills, International Journal of Disaster Risk Reduction 37 (2019) 101150.
[64] D.E. Alexander, Cognitive mapping as an emergency management training exercise, J. Contingencies Crisis Manag. 12 (4) (2004) 150–159.
[65] C.A. Brewer, Basic mapping principles for visualizing cancer data using geographic information systems (GIS), Am. J. Prev. Med. 30 (2) (2006) S25–S36.
[66] S.K. McBride, The Canterbury Tales: an Insider's Lessons and Reflections from the Canterbury Earthquake Sequence to Inform Better Public Communication Models: a Thesis Presented in Fulfilment of the Requirements for the Degree of Doctor of Philosophy in English and Media Studies at Massey University, Doctoral dissertation, Massey University, Wellington, New Zealand, 2017.
[67] R.D. Jacobson, R.M. Kitchin, GIS and people with visual impairments or blindness: exploring the potential for education, orientation, and navigation, Trans. GIS 2 (4) (1997) 315–332.
[68] R. Rener, The 3D printing of tactile maps for persons with visual impairment, in: International Conference on Universal Access in Human-Computer Interaction, Springer, 2017, pp. 335–350.
[69] F. Shiely, K. Hayes, I.J. Perry, C.C. Kelleher, Height and weight bias: the influence of time, PloS One 8 (1) (2013), e54386.